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TRANSLATIONS ON USSR RESOURCES  
(FOUO 13/79)

USSR

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ELECTRIC POWER AND POWER EQUIPMENT

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LONG-RANGE DEVELOPMENT OF USSR FUEL AND ENERGY COMPLEX DISCUSSED

Moscow TEPLOENERGETIKA in Russian No 2, Feb 79 pp 2-6

[Article by Candidate of Economic Sciences A. G. Vigdorchik, Doctor of Economic Sciences A. A. Makarov, and Candidate of Economic Sciences D. B. Vol'fberg]

[Text] The following are the favorable factors which determined the development of the USSR Fuel and Energy Complex (TEK) in the last 20 years and ensured a steady and effective supply of fuel and energy to the national economy: creation of a powerful gas industry, rapid growth of the extraction of oil on the basis of the development of the Ural-Volga and Western Siberian oil-bearing provinces, further development of the coal industry and electric power industry, reconstruction of railway transportation, etc. However, in recent years the cost of organic fuel have shown a clear tendency to rise due to the necessity of developing remote fuel bases with complicated climatic conditions, the decrease in the provision of resources by the achieved levels of extraction in the main oil-and-gas-bearing regions of the European part of the USSR, and the constant tightening of ecological requirements. This can be eliminated only by a large-scale involvement of nuclear energy and coal in the energy balance. The selection of the most rational ways and means of solving this major national economic problem is one of the most important tasks of power engineering.

Changes in the conditions of TEK development will eventually have a great effect on its structure both in the part of production, and in the part of the consumption of fuel and energy resources (TER). Investigation of all aftereffects of impending changes will require much effort and time, but it is possible to reveal the most important of them even now [1].

Energy Consumption. Energy consumption is characterized most objectively by the final energy which is used directly in production, transportation, municipal, and domestic processes. It is difficult to measure it directly, and it is usually determined by computations on the basis of the consumption of the energy supplied (in the form of one or another energy carrier) and the thermal efficiency of the energy-consuming apparatus.

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A retrospective analysis of the scale and structure of the consumption of final energy by the national economy has shown that the main quantitative characteristic of energy consumption -- energy intensiveness of the national income -- decreased by less than 5% in the last 20-25 years, i.e., remained practically invariable. As can be seen from Table 1, this was due chiefly to the constancy of the consumption of final energy in industry per unit of conventionally net product (with a decrease of its consumption per unit of gross product), which is a result of a relative stability of the sectorial structure of industrial production. Some decrease in energy intensiveness which could have been expected due to an increase in the share of machine building with a low energy intensiveness has been compensated by relatively rapid development of the more energy-intensive chemical industry, as well as by increased consumption of the final energy in other sectors of industry in connection with the complication of the conditions of raw material extraction, a decrease in the content of useful substances in raw materials, and the improvement of the quality of products, particularly in metallurgy.

However, agriculture and transportation have shown some increase in energy intensiveness compensated chiefly by a relative decrease in the energy intensiveness of municipal economy (calculated per unit of national income).

Evidently, it is possible to consider that, with the favorable conditions of the development of power engineering during the last 20 years, the stability of the main indexes of energy intensiveness of the national economy at the level of final energy consumption was economically justified.

However, under the new conditions, it is necessary to pursue a purposeful policy of reducing energy intensiveness of the entire material production, and first of all of industrial production. Calculations show that, as a result of the forthcoming changes in the sectorial structure of industrial production (in part, as a result of the realization of the material-saving tendencies) and progressive changes in technology, it is possible to achieve a decrease in the energy intensiveness of the entire material production (by 5-10%), although in transportation, agriculture, and some industrial processes, the effect of factors leading to its increase will continue.

A considerably greater decrease in energy intensiveness should be expected as a result of the improvement of the structure of energy carriers and the energy consuming apparatus, as a result of increasing the energy effectiveness of the generation of electric and thermal energy, as well as a result of the implementation of a large complex of measures for reducing the losses of energy resources.

In order to go from the need in the final energy to the prediction of the consumption of energy carriers (electric power, steam and hot water, fuel), it is necessary to know the structure of energy consumption along the directions of the final utilization of energy. Its dynamics during the past period and predictions as computed by the authors are shown in Figure 1. The same figure shows the participation of various energy carriers in covering the main directions of the final utilization of energy. The determination of this

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participation is, probably, the most labor-consuming and unformalized part of the prognostication of energy consumption which required a thorough analysis of a large number of energy-consuming processes. It showed that the main direction for the improvement of energy consumption is still the electrification of production and domestic processes, but unlike the preceding periods, with electric energy replacing high-quality fuels, such as gas and oil products. Table 2 shows that 35-40% of the increment of the electric energy consumption could be used during the forthcoming period for replacing high-quality types of fuel. The increase in the share of centralized heat supply is going in the same direction, with steam and hot water replacing organic fuels.

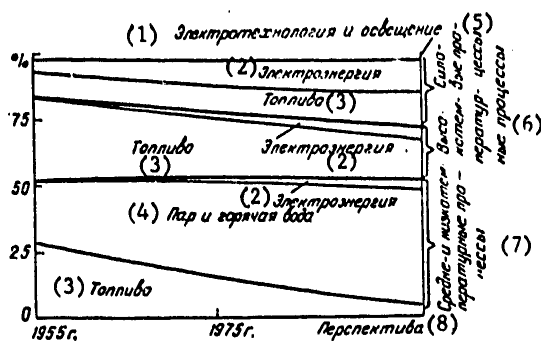


Figure 1. Structure of Final Energy Consumption (by useful consumption).

Key: 1. Electrotechnology and illumination  
 2. Electric energy  
 3. Fuel  
 4. Steam and hot water  
 5. Power processes  
 6. High-temperature processes  
 7. Medium-temperature and low-temperature processes  
 8. Prospects

Table 1 shows the values of the total energy intensiveness (by the consumption of primary energy resources) and the electric-power-intensiveness of the national economy. The total energy intensiveness of the national income during the entire period under examination decreases approximately at the same rate as the coefficient of useful utilization of the energy resources increases (Figure 2). In the future, it is possible to expect its further decrease (by 10-15%). The total energy intensiveness of the conditionally net production of industry will be decreasing at approximately the same rate, and that of the gross production will be decreasing noticeably faster (by 25-30%).

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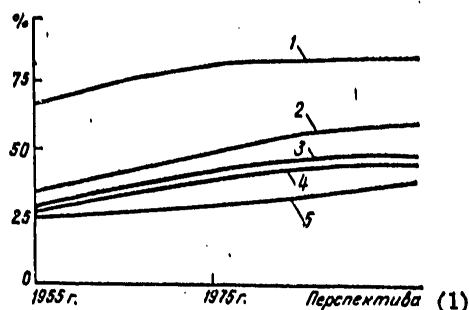


Figure 2. The Dynamics of the Mean Values of the Efficiency of Conversion of Fuel to Final Types of Energy and Energy-Carriers.

1 -- production of steam and hot water; 2 -- conversion of fuel to high-potential thermal energy; 3 -- overall utilization factor of energy resources; 4 -- production of electric energy; 5 -- conversion of fuel to mechanical energy.

Key: 1. Prospects

Table 1  
Total Energy-Intensiveness<sup>1</sup> and Electric-Power-Intensiveness  
of the National Economy of the USSR

	1955 r.	1960 r.	1965 r.	1970 r.	1975 r.	1980 r.
(1) Энергоемкость по конечному потреблению энергии, Гкал/1000 руб.: национального дохода (2) .. 11,7 11,5 11,5 11,2 11,2 11,2 условно-чистой продукции промышленности (3) .. 9,65 9,31 10,7 9,45 9,40 9,5 валовой продукции промышленности (4) .. 5,8 5,3 5,3 4,8 4,3 4,1						
(5) Энергоемкость по валовому расходу топливно-энергетических ресурсов, т в. т./1000 руб.: национального дохода (2) .. 5,85 4,8 4,8 4,0 3,85 3,70 условно-чистой продукции промышленности (3) .. 4,25 3,60 3,60 3,35 3,20 3,10 валовой продукции промышленности (4) .. 2,45 2,05 1,75 1,70 1,47 1,32						
(6) Электроёмкость, кВт·ч/руб.: национального дохода (2) .. 1,85 2,05 2,60 2,65 2,80 3,00 условно-чистой продукции промышленности (3) .. 2,00 2,15 2,65 2,40 2,50 2,60 валовой продукции промышленности (4) .. 1,20 1,20 1,32 1,20 1,18 1,10						

<sup>1</sup>Without export and consumption of fuel as raw or other material.

Key: 1. Energy-intensiveness by the final energy consumption, Gcal/1000 rubles:

2. of national income

3. of conventionally net product of industry

4. of gross product of industry

5. Energy-intensiveness by the gross consumption of fuel and energy resources, tons of reference fuel/1000 rubles:

6. Electric-power-intensiveness, kWh/ruble:

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The electric-power-intensiveness of the national income and the conditionally net production of industry has been steadily increasing and, as calculations show, will be increasing in the foreseeable future (an increase of 10-15%), and the expected decrease of the electric-power-intensiveness of the gross production of industry which started in the seventies reflects not the nature of the occurring processes, but the peculiarities of the calculation of this index.

According to the dynamics of the indexes of energy-intensiveness and electric-power-intensiveness of the national economy shown in Table 1 and the projected doubling of the country's economic potential in fifteen years<sup>1</sup>, it is possible to expect the doubling of the overall energy consumption in 16-18 years and the doubling of electric power consumption in 13-14 years. It is these parameters that determine the requirement of the national economy for the scale of the TEK development.

Production of Fuel and Energy Resources. The changes occurring in the conditions of the development of TEK reflect on its production structure to a still greater degree than on the size and structure of energy consumption.

The sectorial structure of TEK is undergoing fundamental changes. Their essence can be formulated in the following way: the policy of radical improvement of the fuel and energy base by sharply increasing the share of oil and particularly natural gas during the Tenth Five-Year Plan set by the 21st CPSU Congress is, basically, achieving its goals. Subsequently, it will be expedient to stabilize and slowly reduce the share of high-quality types of fuel in the fuel and energy balance of the USSR.

In this connection, provisions are made in the resolutions of the 25th CPSU Congress for a wider use of coal, schist, hydraulic energy, and nuclear energy along with oil and gas. Figure 3 illustrates the changes in the proportions among the main natural sources of energy obtained as a result of studying the optimal directions of long-range TEK development (the content and main stages of such studies were given earlier [2]).

The possibilities and the pace of the realization of the above-mentioned changes in the sectorial structure of TEK and the national economic effectiveness are determined by a whole complex of measures. The most important of them are described below.

Conditions of fuel supply of main categories of consumers have a decisive significance for the determination of a rational production structure of TEK. At the present time, high-quality types of fuel are used chiefly to satisfy the transportation and technological needs of industry and of the majority of boiler rooms (with the exception of a part of the eastern regions of the country). Moreover, gas and mazut are used by the majority of electric power

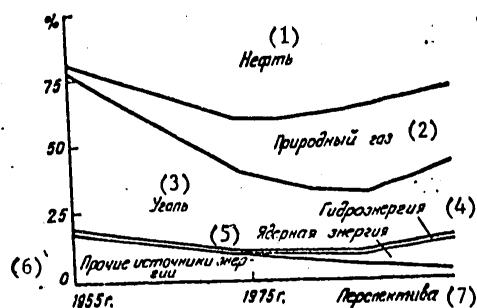
1. "Materialy XXV s'yezda KPSS" (Materials of the 25th CPSU Congress), Moscow, Politizdat, 1976, p 40.

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**Table 2**  
Main Directions of the Replacement of High-Quality  
Fuel with Electric Energy (possible variant)

(1) Энергопотребляющие процессы	(2) Доля в общем приросте по- требности в электрической энергии по сравнению с 1975 г., %	(3) И том числе	
		(4) на заме- ну жидко- го топлива, %	(5) на заме- ну газо- вого, %
(6) Среднесрочная перспектива (всего)	3,5	1,6	2,0
Силовые: (7)	12	4	8
стационарные . . . (8) . . .	8	—	8
нестационарные . . . (9)	4	—	—
(10) Высокотемпературные . . . (10) . . .	13	4	—
(11) Средне- и низкотемпературные	10	1,6	11,5
Долгая перспектива (всего) (12)	38	9,6	21
Силовые: (7)	14	5,6	8,5
стационарные . . . (8) . . .	8,5	—	8,5
нестационарные . . . (9) . . .	5,5	5,6	—
(10) Высокотемпературные . . . (10) . . .	12	—	11
(11) Средне- и низкотемпературные	12	10,6	1,5

- Key: 1. Energy-consuming processes  
2. Share in the overall increment of needs in electric energy in comparison with 1975, %  
3. Including  
4. For replacement of fuel oil, %  
5. For replacement of gas, %  
6. Medium-term prospects (total)  
7. Power:  
8. stationary  
9. nonstationary  
10. High-temperature  
11. Medium-temperature and low-temperature  
12. Long-range prospects (total)



**Figure 3. Structure of the Extraction (production) of  
Natural Energy Resources**

- Key: 1. Oil  
2. Natural Gas  
3. Coal  
4. Hydraulic Energy  
5. Nuclear Energy  
6. Other sources of energy  
7. Prospects

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stations (not only TETs, but also KES [condensation electric power plants]) in the European regions of the country and in Central Asia. But many small thermal units (individual furnaces and the boiler rooms) which determine comfortable living of a part of the population still cannot be switched to operation with a high-quality fuel.

Table 3  
Evaluation of the Share of Principal Energy Resources  
of the Main Categories of Consumers, %

Потребители (1)	(2) Современное состояние			(3) Перспектива		
	(4) газ + мазут	(5) ядерная энергия	(6) уголь	(7) газ + мазут	(5) ядерная энергия	(6) уголь
Электростанции (8)...	45 27	7	42	13-12	36-39	50-47
В том числе: (9)						
КЭС (10)....	33 21	16	47	3	30-40	60-66
ТЭЦ (11)....	15 32	—	37	30-29	35-28	33-31
Котельные (12)...	70 23	—	19	76-73	3-5	21-22
(13) Мелкие тепловые установки	13 1	—	46	39-40	0-1	25
(14) Технологические установки	43 10	—	8	52	1-3	3

Key: 1. Consumers  
2. Present state  
3. Future prospects  
4. Gas + mazut/mazut  
5. Nuclear energy  
6. Coal  
7. Gas + mazut  
8. Electric power stations  
9. Including:  
10. KES  
11. TETs  
12. Boiler rooms  
13. Small thermal units  
14. Technological units

In the future, the increase in the cost and the relative scarcity of high-quality fuel should not reflect on its share in the fuel supply to transportation facilities and technological consumers (Table 3), although it will somewhat reduce it as a result of accelerated electrification of power and high-temperature processes. Proceeding from economic and, chiefly, social considerations, it will be necessary to improve substantially energy supply to small heat consumers acting both in the direction of absolute decrease of direct burning of fuel for these purposes (through centralization of heat supply and partly electrification), and by satisfying them to a greater degree with high-quality fuels: gas and distillate. At the same time, the composition of energy resources for boiler rooms and, particularly, electric power stations should also change. Under the new conditions, additional amounts of high-quality fuels must be allocated for specialized (primarily, for peak consumption) operating and some expanded gas-mazut electric power stations (primarily TETs), as well as low-capacity and medium-capacity boiler rooms in the European part of the country. However, large boiler rooms (and

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partly TETs) will be the final consumers of high-quality fuels, and its share will remain stable or will be decreasing somewhat as a result of a more extensive use of coal (chiefly in industrial boiler rooms in the eastern regions of the country) and later, evidently, of nuclear energy. It is important to stress that, under the emerging conditions, this solution is, on the whole, rational and economically justifiable, but will require extensive work on substantiating the conditions of fuel supply to concrete consumers (with consideration for ecological factors and other local conditions) which will inevitably amend the evaluation of the overall structure of fuel supply. On the whole, however, as was shown by multivariant optimization calculations of TEK, in principle there are no restrictions on the part of the consumers on the rearrangement of the sectorial structure of TEK in the direction of stabilization and subsequent decrease of the share of high-quality fuel.

Such restrictions could appear if we examined the roles of various types of high-quality fuels more carefully. In fact, as can be seen from Figure 3, it is expected that the share of oil in the balance of natural sources of energy will decrease considerably during the forthcoming period while the share of natural gas will increase, and will become stabilized only in a remote future). The decrease of the share of oil must reflect particularly strongly on the volume of mazut production, since the need in clear petroleum products will, evidently, be increasing. In turn, the decrease in the use of furnace mazut in the energy balance could entail definite difficulties with fuel supply to consumers using natural gas in winter, since in the near future the gas supply system will still be unable to satisfy all needs in natural gas during a period of its maximum consumption. Calculations have shown, that, with the expected decrease in the share of oil, the active capacity of gas storage facilities must increase 10-15 times in comparison with 1975 (in the medium-range period and in the long-range period, respectively).

In turn, the decrease in the production of mazut will require a multiple increase in the capacities of the secondary processes of oil refining or changes in the structure of export (petroleum products instead of a part of raw petroleum). In a more remote future, there will probably occur the necessity of producing artificial liquid fuel.

The realization of the entire complex of measures for changing the system of the regulation of fuel supply and structure of fuel processing, primarily, a considerably more thorough processing of petroleum, is connected with definite difficulties. This problem requires much attention since delays in its solution can directly reflect on the rate of changes in the sectorial structure of TEK.

The stabilization and the subsequent decrease in the share of high-quality types of fuel will be compensated during the next period by the accelerated development of a new branch of TEK -- nuclear power engineering. Studies have shown the economic practicality and balance necessity of increasing the share of nuclear energy in the fuel and energy balance to four percent during a medium-range prediction period and 6-8% during a remote prediction period, and, therefore, the general share of high-quality energy resources (oil, gas,

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atomic and hydraulic energy) will continue to increase. Moreover, nuclear power engineering does not only replace high-quality fuel, but it also competes with the coals of the eastern and, particularly, European fields. In the maximum variant, nuclear energy is responsible for almost the entire increase in the basic electric load (including a considerable part of the increment in TETs capacities) in the European regions of the country, as well as a considerable percentage of heat production (in particular, by atomic boiler rooms)<sup>2</sup>.

In a lower variant, atomic boiler rooms are replaced to a considerable degree by boiler rooms working on natural gas, a part of the capacities of atomic TETs -- by maneuverable TETs operating on coal, and atomic KES (in the Ural and Volga regions) -- by direct-current electric power transmission lines from Siberia and, possibly, by coal-operated KES. According to optimization calculations, the losses connected with this reach 3-6 rubles/ton of reference fuel.

In the final analysis, the lowering of the level of the development of nuclear power engineering must be compensated by an increase in the extraction of coal, chiefly, from the Kuznets and Kansk-Achinsk fields. In the future, the main sphere of the interchangeability of these energy resources will become the production of not only electric energy, but also of heat energy. In a remote future, up to 50% of the produced nuclear energy will, evidently, be used by TETs, boiler rooms, or heat supply systems through dissociating energy carriers. The conditions of its interchangeability with coal require a thorough technical and economic study which is just beginning. In these studies, along with the degree of readiness of the equipment and thorough development and reliability of the energy-supply systems, it is necessary to consider the great intensity of the program for the development of the coal industry even in the variant of an accelerated development of nuclear power engineering. As can be seen from Figure 3, under these conditions, the share of coal in TEK is stabilized at level of approximately 25% with a certain tendency toward an increase by the end of the period.

The territorial structure of TEK changes in the period under consideration even more than sectorial structure. This is determined by the fact that practically all increment of the extraction of organic fuel is concentrated in the eastern regions of the country, chiefly in Siberia. As a result of this, the streams of all types of fuel from the eastern regions to the European regions increase rapidly: 3-4.5 times in comparison with 1975 during medium-range and distant periods. Due to this, the share of imported fuel in the energy supply system of the European part of the country, even with accelerated development of nuclear power engineering, will increase to 48-50%, and will become stabilized only in the distant future. Moreover, the prevailing increase of the streams of oil and gas by the end of the period will, evidently, be replaced by a relative increase in the use of coal or the production of

<sup>2</sup> It is also expected that nuclear energy will start being used for technological needs directly or with the use of hydrogen.

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electric energy and its subsequent transmission to the central regions of the country, as well as its transportation by railroad and, possibly, through pipelines. The transportation of the Kansk-Achinsk coal will become effective provided its technological processing is introduced industrially.

**Closing Costs of Fuel.** Changes in extraction, distribution, and use of fuel discussed above reflect substantially on the methods of the formation and numerical values of closing expenditures -- proportionate economic indexes characterizing aggregate national economic expenditures on ensuring additional needs in various types of fuels and energy by the regions of the country (the principles of the formation and the areas of the application of closing expenditures were explained earlier [4]).

The world market conditions of prices on oil and gas may have a definite effect on closing expenditures. Maintaining their modern high level objectively leads to a desire to increase the export of high-quality fuel. In this case, in order to satisfy domestic needs in energy resources, it may become necessary to maintain or even increase the extraction of a lower quality and more expensive fuel, primarily coal. This fact and the relative value of high-quality fuel, all other things being equal, raise the level of the closing expenditures on all types of fuel and energy.

**Table 4**  
Long-Term Values of Closing Expenditures on Gas and Coal,  
Rubles/Ton of Reference Fuel

Районы (1)	(2) Газ	(3) Уголь	
		Каменный	Сыгунга
Северо-Запад (6) (7) . . . . .	41-43	35-37	—
Центр . . . . .	40-42	34-36	—
Северный Кавказ . . . . . (8)	41-43	32-34	—
Поволжье . . . . . (9)	37-39	30-32	—
Урал . . . . . (10)	35-37	27-29	—
Западная Сибирь . . . . . (11)	27-28	17-19	12-14
Восточная Сибирь . . . . . (12)	23-25	13-15	6-9
Забайкалье . . . . . (13)	—	16-18	12-14
Дальний Восток . . . . . (14)	27-29	20-22	18-20
Восточная Украина . . . . . (15)	40-43	31-33	—
Западная Украина . . . . . (16)	43-45	33-35	—
Прибалтика, Белоруссия . . . . . (17)	43-45	35-37	—
Закарпатье . . . . . (18)	43-45	34-36	—
Средняя Азия . . . . . (19)	28-31	20-22	—
Казахстан . . . . . (20)	31-33	18-20	—

- |                      |                              |
|----------------------|------------------------------|
| Key: 1. Regions      | 11. Western Siberia          |
| 2. Gas               | 12. Eastern Siberia          |
| 3. Coal              | 13. Trans-Baikal area        |
| 4. Hard              | 14. Far East                 |
| 5. Brown             | 15. Eastern Ukraine          |
| 6. Northwest         | 16. Western Ukraine          |
| 7. Center            | 17. Baltic areas, Belorussia |
| 8. Northern Caucasus | 18. Transcaucasia            |
| 9. Volga River area  | 19. Central Asia             |
| 10. The Urals        | 20. Kazakhstan               |

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Just as before, the closing expenditures on fuel during the entire prediction period are based on direct proportionate calculated (with consideration for the time factor) costs of the extraction and interrayon transportation of coal chiefly from the Donets and Kuznets basins (Table 4). Moreover, in many "old" basins (for example, in the Donets Basin), the closing expenditures on the extraction of coal are also formed by reconstructed enterprises where the calculated expenditures on the increment of extraction are sometimes higher than those of new enterprises. It is notable that the expenditures on nuclear sources of energy approach in their significance directly the expenditures on the extraction (and transportation) of closing coals (calculated per one ton of reference fuel). This fact increases substantially the stability of this level of closing expenditures.

The closing expenditures on gas are formed by the expenditures on coal in the Center, in North-West, and the Ukraine with consideration for the interchangeability of these types of fuel for the ultimate consumer (boiler rooms), where the loss from the use of coal instead of gas amounts to 7-10 rubles/ton of reference fuel. In the remaining regions of the country, the closing expenditures on gas are formed by subtracting the proportionate expenditures on its transportation through pipelines.

The closing expenditures on petroleum products acquire great importance in the period under consideration. For mazut, they are formed on the basis of its interchangeability with natural gas for satisfying the peak needs in fuel consumption in the central regions of the country; the difference in the cost (with consideration for the cost of gas storage facilities and gas distribution networks) reaches 6-8 rubles/ton of reference fuel.

The closing costs on mazut, in turn, determine the indexes of clear petroleum products (gasoline and diesel fractions) by adding proportionate costs of secondary processes of oil refining. As a result of this, the values of the closing expenditures on the main fractions of oil refining are formed. With consideration for these indexes weighed by the proportions of the yield of various fractions from crude oil, closing expenditures are determined for light and heavy oils.

Thus, changes in the conditions of the development of the USSR TEK, in the long term, will bring about fundamentally new tendencies in the development of energy consumption and in the fuel and energy base proper, as well as changes in the economic indexes of the fuel and energy resources. The main tendencies show themselves sufficiently reliably, but many concrete problems (some of which were named above) still need to be examined thoroughly, and rational solutions have often to be sought in entirely new areas. Since concrete measures for TEK reconstruction are already being prepared and are beginning to be implemented, rapid solution of these problems is becoming particularly urgent.

## Bibliography

1. Melent'yev, L. A. IZVESTIYA AN SSSR. ENERGETIKA I TRANSPORT, 1977, No 5.

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2. Makarov, A. A. TEPLOENERGETIKA, 1977, No 9.

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AREAS FOR SMALL-CAPACITY NUCLEAR TETS IN EXTREME NORTH DESCRIBED

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[Text] One of the main problems for the northern regions of the country is to provide fuel and energy resources for the steadily growing energy consumption.

The long-range planning and the increasing pace of the industrial development of the Extreme North regions require that the problems of the formation of rational systems of heat supply to populated centers and industrial enterprises should be examined in an integrated way when developing city-building, industrial, and technological problems.

Heat supply to populated centers and industrial centers under the conditions of the Extreme North is a complicated problem. This complexity is due to the selective development of natural resources, focal arrangement of industry, considerable remoteness from industrially developed regions of the country, low levels of thermal loads, severe climate, long heating season, high costs of the importation of fuel and materials, high proportionate costs of construction [1], and scarcity of manpower resources.

The thermal loads of populated centers and mining enterprises of Extreme North are not heavy and are, as a rule, 20-125 GJ/h, reaching 250-335 GJ/h only in individual instances. At the same time, populated centers of the rayons in Extreme North, due to their natural and climatic conditions, have the highest heat consumption in the country. For example, the heating period for the northern regions of the Yakut ASSR is characterized by a value of 11,500 degree-days, while the same period for the Moskovskaya Oblast is characterized by 4,620 degree-days [2]. Moreover, the working time for the calculated thermal load in these regions is 3500-5000 h/year. Along with this, the delivery of fuel to the place of consumption in the North, as is known, requires considerable expenditures of material and manpower resources.

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Heat is supplied to populated centers and industrial centers chiefly by coal-operated water-heating boiler rooms and TETs. A considerable amount of manpower is needed in order to provide them with fuel. The unreliability of fuel supply connected with the long distances and seasonal nature of transportation makes it necessary to accumulate and store large reserves of fuel for a long time at the places of consumption and at transshipment bases. The reserves of fuel necessary for ensuring uninterrupted (reliable) heat supply sometimes exceed the annual need in fuel.

Therefore, the immediate task for the regions of the Extreme North is to search for ways and means of reducing the importation of fuel and the size of the personnel involved in attending transportation facilities and heat-generating sources.

The use of nuclear energy sources instead of boiler rooms and TETs on organic fuel is one of the promising directions.

The work on the creation of low-capacity nuclear energy sources is carried out in the USSR as a part of the overall program for the development of nuclear power engineering and is directed, primarily, toward solving the problems of energy supply to remote regions of the Extreme North of the country [3, 4].

To date, a considerable volume of work has been done on the creation of a low-power and medium-power nuclear reactors intended for supplying electric and thermal power to remote and almost inaccessible regions of the country. Designs have been completed for units with electric capacities of 1.5, 6, 12, and 25 MW and higher which can be used for the production of electric energy and heat [3-6].

At the present time, nuclear energy sources should be considered one of the most promising types of energy sources for the regions of the Extreme North, because they do not depend on the presence of energy resources in the rayon and can be built directly at places where minerals are mined and provide electric energy and heat to industrial, cultural, and housing facilities.

It is possible to outline the following ways of the realization of nuclear energy in the North for supplying heat to industrial centers and cities:

construction of atomic heat and electric power stations (ATETs);

construction of atomic heat supply stations (AST);

installation of district heating units at atomic condensation electric power stations (AKES) situated near cities;

utilization of unregulated bleeding of condensing turbines of AKES from which heat can be delivered for heating housing facilities.

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The economic practicality of each of these directions must be determined depending on concrete conditions.

This article examines the use of atomic heat and electric power stations (ATETs) for supplying electric power and heat to industrial centers and cities of the North.

The most important problem in creating ATETs is the insurance of radiation safety. As a rule, heat is supplied by extracting steam from a turbine and using it for heating the water in a network which is used for heating in special intermediate circuits where the pressure of the heat carrier is higher than the pressure of the network water and the heating steam, which makes it possible to eliminate the possibility of the penetration of radioactivity to the network water and, thus, guarantees the safety of heating.

The first experiment in the use of the heat of an AKES for district heating in the USSR was done at the Beloyarskaya AES imeni I. V. Kurchatov. The district heating plant constructed there supplies heat at the present time to the industrial construction site of the third unit of the Beloyarskaya AES, to a residential settlement of the power industry workers and to a hothouse enterprise with an area of 8000 m<sup>2</sup>.

The first industrial heating ATETs is the Bilibinskaya ATETs on the Chukchi Peninsula with a power of 48 MW. Its four blocks, each of 12 MW have been operating successfully.

In recent years, scientific-research and design organizations have started to solve the problems connected with the creation of atomic TETs and boiler rooms of medium and high capacities. Specific jobs and studies on the determination of the effectiveness and application areas of ATETs are being done in the Department of Power Engineering of the Institute of Physico-Technical Problems of the North, Yakutsk Affiliate of the Siberian Branch of the USSR Academy of Sciences.

This article examines the condition of achieving effectiveness in the use of ATETs under the conditions of the North depending on the levels of thermal loads, calculated design expenditures on organic fuel, and capital investments into ATETs. The optimization is done by the criterion of minimum design expenditures,  $3_{\min}$ .

The calculations are done for a power supply system realized by constructing sources of thermal energy based on nuclear or organic fuel (ATETs or TETs).

The following variants of combined heat supply systems reduced to an identical energy effect were considered:

ATETs with a standby peak boiler room using organic fuel;

TETs operating on organic fuel.

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We determined comparative effectiveness of an ATETs variant in relation to a TETs variant, the minimal necessary thermal load, and the input of organic fuel and capital investments in an ATETs beginning with which the ATETs becomes more effective than a TETs operating on organic fuel.

ATETs are usually designed with turbines T-6-44 and T-12-60 with a pressure of saturated steam of 4.4 and 6.0 MPa which can be created on the basis of the turbines of the first section of the Novovoronezhskaya AES and Bilibinskaya ATETs, and TETs operating on organic fuel are designed on the basis of the turbines T-6-35 and T-12-35.

The studies were done with the use of the material of the project ATETs "Sever-2" with two integrated water-moderated water-cooled reactors (IVVER) with a unit thermal capacity of 14.5 MW [3, 4, 7], as well as of the designs of TETs working on organic fuel under the conditions of the Extreme North developed in application to the northern regions of Magadanskaya Oblast and Yakut ASSR.

The main initial data taken for the calculations are shown in the table. Since there are no reliable data at the present time on capital investments in ATETs, it was assumed that their values change within a certain range. Capital investments for the reactor part of an ATETs of the "Sever-2"-type with integrated water-moderated water-cooled reactors (IVVER) were taken to be a unity.

Since integrated water-moderated water-cooled reactors with natural circulation of the heat-transfer agent are sufficiently safe [5,6], the distance of the ATETs to the consumer of heat was taken to be the same as for a TETs of the corresponding power operating on organic fuel.

The peak sources of heat for ATETs were boiler rooms working on organic fuel. Climatic conditions were assumed to be characteristic of the northern regions of the country.

Calculations done for normal and emergency (nuclear reactor failure) modes of ATETs operation showed that the optimal solution is to install one or two nuclear reactors and standby peak-hour water heating boilers working on organic fuel at the ATETs. In determining the effectiveness of the use of TETs and ATETs, each power unit was considered to be working under the conditions optimal for it, i.e., with an optimal make-up of the main equipment, determined depending on the thermal load level.

Figure 1 shows the changes in the economy ( $\Delta$ ) or overexpenditure ( $+\Delta$ ) of calculated expenditures on an ATETs in comparison with an ordinary TETs for a thermal load for household heating. It can be seen from the curves of Figure 1 that atomic TETs become competitive only when there are definite combinations of expenditures on organic fuel ( $30_T$ ) and capital investments in the ATETs.

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Table  
Initial Data Taken for Calculations

Наименование показателей (1)	Расчетные значения (2)
Расчетная тепловая нагрузка, ГДж/ч . . . (3)	105—335
Доля нагрузки горячего водоснабжения (от расчетной нагрузки в горячей воде) . . . (4)	0,2
Число часов использования расчетного максимума тепловой нагрузки, ч/год . . . (5)	4000
Единичная электрическая мощность АТЭС, МВт (6)	0—24
Расчетные затраты на органическое топливо, руб/т в т. . . (7)	50—300
Коэффициент удорожания строительства-монтажных работ в северной климатической зоне . . . (8)	3
Капиталовложения АТЭС (9)	
максимальные . . . (10)	1,2
средние . . . (11)	1,0
минимальные . . . (12)	0,8

\*Capital investments of ATETs of the "Sever-2"-type are taken as unity.

- Key: 1. Indexes  
 2. Calculated values  
 3. Calculated thermal load, GJ/h  
 4. Share of the load of hot water supply (of calculated load in hot water)  
 5. Number of hours of the use of calculated maximum of thermal load, h/year  
 6. Unit electric capacity of ATETs, MW  
 7. Calculated costs of organic fuel, rubles/ton of reference fuel  
 8. Cost increase coefficient of construction and installation jobs in the northern climatic zone  
 9. Capital investments of ATETs\*:  
 10. Maximum  
 11. Medium  
 12. Minimum

For example, when the calculated thermal load is  $Q_{0,p} = 105$  GJ/h, atomic TETs with integrated water-moderated water-cooled reactors are economical only when the expenditures on organic fuel are  $30_{0,T} = 190 \div 270$  rubles/ton of reference fuel with minimum and maximum capital investments in the ATETs, respectively.

When the thermal load level  $Q_{0,p}$  increases to 335 GJ/h, the ATETs becomes more economical and the competitiveness of the atomic TETs is attained at expenditures on organic fuel  $30_{0,T}$  of 50 and 100 rubles/ton of reference fuel. As can be seen from the curves, the effectiveness of atomic TETs is substantially influenced by capital investments and levels of thermal loads.

On the basis of the curves plotted in Figure 1, it is possible to establish the dependence of a minimal practical thermal load for an atomic TETs on capital investments and expenditures on organic fuel. This dependence is shown in Figure 2. It follows from these curves that, when capital investments

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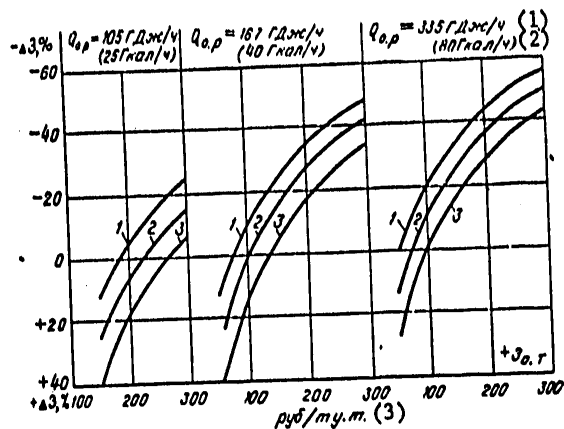


Figure 1. Changes in the economy ( $-\Delta 3$ ) or overexpenditure ( $+\Delta 3$ ) of calculated expenditures on ATETs with integrated water-moderated water-cooled reactors in comparison with a TETs working on organic fuel for various levels of thermal loads for household heating and calculated costs of fuel.  
1-3 -- minimum, medium, and maximum capital investments in ATETs

Key: 1. GJ/h  
2. Gcal/h  
3. rubles/ton of reference fuel

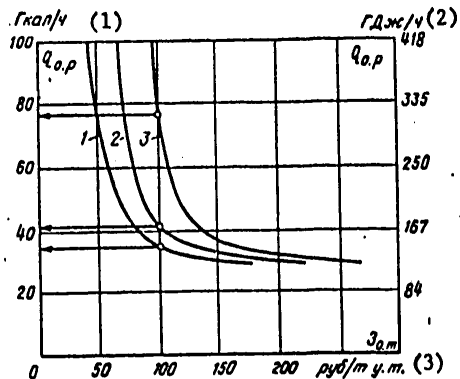


Figure 2. Changes in the minimally practical load at an ATETs with integrated water-moderated water-cooled reactors depending on capital investments and calculated costs of organic fuel.  
1-3 -- see Figure 1

Key: 1. Gcal/h  
2. GJ/h  
3. rubles /ton of reference fuel

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decrease from maximum to medium, the minimum thermal load for an atomic TETs drops from 335 to 167 GJ/h with expenditures on organic fuel of 100 rubles/ton of reference fuel.

At the same time, when the expenditures on organic fuel are higher than 150 rubles/ton of reference fuel, the changes in capital investments do not have such a substantial effect on the minimal thermal load  $Q_{0,p \text{ min}}$  of an atomic TETs (Figure 2).

This analysis brings up the problem of real long-range changes in the expenditures of organic fuel in the regions of the Extreme North, since the economic practicality of the use of low-capacity ATETs depends on the expected range of their variation. Calculations performed in the laboratory of general power engineering of the Institute of Physico-Technical Problems of the North, Yakutsk Affiliate of the Siberian Branch of the USSR Academy of Sciences showed that the cost of organic fuel for such fuelless regions of the Yakut ASSR as the basins of the rivers Olenek, Yana, Anabar, and others will be about 150-200 rubles/ton of reference fuel [7], which creates the condition for studying and substantiation of the use of low-capacity atomic TETs in these regions.

In the Yakut ASSR, the top priority industrial centers for possible use of low-capacity atomic TETs with integrated water-moderated water-cooled reactors could be industrial settlements of Ust'-Yanskiy Rayon with thermal loads over 180 GJ/h (45 Gcal/h) and the cost of organic fuel in these regions of 100-150 rubles/ton of reference fuel and higher.

Conclusions

1. The absence of fuel deposits in some northern regions of the country makes it necessary to study the problems of using nuclear energy for supplying heat to cities, settlements, and industrial centers by constructing atomic heat and electric power stations (ATETs).
2. In some instances it is justified to use low-capacity ATETs widely, because the calculated expenditures on organic fuel  $3_{0,T}$  for many regions of the Extreme North of the country reach 100-200 rubles/ton of reference fuel.
3. In selecting the type of the heat-supply source, the final decision can be made only on the basis of detailed studies and economic calculations performed with consideration for the conditions of a concrete construction site for an ATETs.
4. The use of nuclear fuel in the regions of the Extreme North can reduce the consumption of expensive organic fuel transported from distant areas. For example, the following indexes characterize the saving that can be achieved: by constructing an ATETs with a heat-generating capacity of 335-650 GJ/h in the North, it will be possible to save 60,000-120,000 tons of reference fuel annually, which will produce an annual saving of approximately 10-15 million rubles.

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5. The results of studies have shown that it is practical to use nuclear fuel for district heating systems, which will be one of the possible and promising directions in the improvement of the fuel and energy management of the northern regions of the country.

Bibliography

1. "Ekonomika stroitel'stva v usloviyakh Severnoy stroitel'no-klimaticheskoy zony (tekhniko-ekonomicheskiye pokazateli i kharakteristiki)" [The Economics of Construction Under the Conditions of the Northern Climatic Construction Zone (Technical and Economic Indexes and Characteristics)]. Reference Manual, Krasnoyarsk, 1971.
2. "Metodika normirovaniya i normy raskhoda topliva na otopleniye zdaniy i khozyaystvenno-bytovyye nuzhdy v Yakutskoy ASSR" [Methods of Normalization and Norms of Fuel Consumption for Heating Buildings and Household Needs in the Yakut ASSR], Yakutsk, 1974.
3. "Atomnoy energetike XX let" [Twenty Years of Atomic Power Engineering], Moscow, Atomizdat, 1974.
4. Petros'yants, A. M. "Ot nauchnogo poiska k atomnoy promyshlennosti" [From Scientific Research to Atomic Industry], Moscow, Atomizdat, 1972.
5. Zhil'tsov, V. A.; Kotov, A. P.; Merzlikin, G. V., et al. "The Use of Water-Moderated Water-Cooled Reactors in Small-Scale Atomic Power Engineering," ATOMNAYA ENERGIYA [Atomic Energy], 1969, Vol 26, No 5.
6. Sergeyev, Yu. A. "Prospects for the Use of Small Atomic Energy Sources in the Northern Regions of the USSR," KOLYMA, 1969, No 11.
7. Shadrin, A. P. "Prospects for the Use of Small Atomic Stations for Heat Supply in the Regions of the Extreme North of the Yakut ASSR," in the book "Osnovnyye napravleniya razviciya i zadachi optimizatsii energeticheskogo khozyaystva Yakutii" [Main Directions of the Development and Optimization Problems of the Energy Management System of the Yakut ASSR], Yakutsk, 1976.

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FUELS AND RELATED EQUIPMENT

CHANGES IN EFFICIENCY OF FUEL AND ENERGY COMPLEX ANALYZED

Moscow VOPROSY EKONOMIKI in Russian No 3, Mar 79 pp 21-32

[Article by V. Fal'tsman and I. Zasorina: "Output-Capital Ratio and Capital-Output Ratio in the Fuel-Energy Complex"]

[Text] At the November (1978) Plenum of the CC CPSU, L. I. Brezhnev noted that the search for the most efficient and economical methods of attaining final production results should be at the center of all work on the new five year plan. Greater attention should be given both to intersector and intra-sector proportions and the acceleration of scientific-technical progress.

The main socio-economic consequences of the development of the fuel and energy complex (FEC) are the thorough electrification of the nation, the satisfaction of the national economy's requirements with its own energy resources, and increases in the exports of these resources.<sup>1</sup> Labor productivity growth is accelerating in FEC sectors. During 1961-1966 it grew by 26 percent and the last two five year plans by 180 percent.<sup>2</sup> Nevertheless, the development of FEC sectors is accompanied by negative consequences such as the reduction of output-capital ratios and the growth of capital-output ratios.

During 1971-1975 the capital-output ratio in the FEC increased by 10-15 percent in comparison to 1966-1970.<sup>3</sup> The growth in this ratio can be observed both in the production of electrical energy and in the fuel industry (See Table 1). Within the fuel sectors, the capital output ratio grew most significantly in petroleum extraction. In 1975 the output-capital ratio in the FEC was 18 percent lower than in 1966, and almost 30 percent lower than in 1961, i.e. it had an annual decline of about 2 percentage points. The reduction in this ratio occurred in electrical power engineering and in all fuel extraction sectors.

During the Tenth Five Year Plan the capital-output ratio of the FEC continues to grow. According to our estimates, capital investments to attain a 1 ton increase in standard fuel extraction from West Siberian deposits during the Tenth Five Year Plan will be 1.3 fold higher than in the Ninth Five Year Plan.

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Table 1.  
Dynamics of Capital-Output Ratio and Output-Capital Ratio in Fuel and Energy Complex (FEC) Sectors\* (Rubles/Rubles)

Sector	1961- 1965	1966- 1970	1971- 1975	1971- 1975	1975
				1961- 1965	1961
1. Capital Output Ratio					
FEC	4.05	4.12	4.74	1.17	-
Including					
Electrical					
Energy					
Production	3.36	3.32	3.63	1.08	-
Fuel Industry	4.52	4.65	5.44	1.20	-
2. Output-Capital Ratio (for First, Second, and Last Year of the Ninth Five Year Plan)					
FEC	0.56		0.40		0.71
Including					
Electrical					
Energy					
Production	0.29		0.23		0.79
Fuel Industry	0.82		0.64		0.78

\* The calculations use data on gross output, capital investments and fixed productive capital in constant prices. Calculated during the period 1965-1976 using data from the statistical annual Narodnoye khozyaystvo SSSR v 1975, pp 57, 196-197, 508, 223, 58; for 1961-1965 using data from analogous TsSU [Central Statistical Administration] annuals for the preceding years. Output-capital ratios calculated as ratios of annual output volume to fixed industrial-productive capital at the beginning of the year. Capital-output ratios are the ratios of total capital investments during the five year plan to the corresponding growth in output, with a 1 year lag.

These tendencies, negative for the national economy, were especially marked as a result of the quite high percentage of investments in the FEC, and the pace setting development of its sectors' production apparatus: in 1971-1975 more than 25 percent of productive capital investments in industry were allocated to the development of the complex. The FEC's share of fixed productive capital grew. The share of four sectors: electrical energy, petroleum extraction, and the gas and coal industries, accounted for more than 90 percent of capital investments in the fixed capital of the complex.

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Scientific-technical progress in the FEC above all involves improvements in the structure of the fuel-energy balance. During the period analyzed, with a total growth in fuel extraction of 1.6 fold (calculated in standard units), the production of electrical energy, especially atomic, grew at pace setting rates (2 fold). Great structural changes occurred in fuel extraction: the share of petroleum increased from 36 to 44 percent, that of gas from 15 to 22 percent, coal's share declined from 43 percent to 31 percent, and there were marked reductions in the share of peat and firewood.<sup>4</sup>

The influence of changes in FEC structure on the output-capital ratio is estimated with the help of the relationship:  $J_r = r \cdot \sum \frac{d_j}{r_j}$ , where  $r$  -

the actual output-capital ratio;  $r_j$  - the output-capital ratio for the  $j$ th sector of the FEC in 1975 ( $j = 1, 2, 3, 4$ );  $d_j$  the share of the  $j$ th sector in FEC output in 1966. The index characterizing the effect of FEC structural changes on the capital-output ratio was computed using the formula:

$J_q = q : \sum d_j q_j$ , where  $q$  is actual FEC capital output ratio during 1971-1975;  $q_j$  capital-output ratio of the  $j$ th sector during 1971-1975,  $d_j$  the share of the  $j$ th sector in total FEC capital investments during 1966-1970.

As studies have indicated, changes in FEC structure have a greater influence on output-capital ratios than on capital-output ratios (the output-capital ratio was reduced by 8 percent while the capital-output ratio increased by 2 percent). The most marked intrasectoral changes in the FEC (the growth in the percentage of TEC (Thermal electric station) output and the reduction of the percentage of GEC (Hydroelectric station) in electrical power production; the increased percentage of enrichment in the coal industry, the pace setting growth of the natural gasoline subsector of the gas industry) all had an insignificant effect on the indicators being analyzed and had practically no influence on the output-capital ratio of electrical power production, while for the gas and coal industry the ratio was reduced to 1 percent.

The effects of repeated counting during the determination of the gross output volume of each sector are taken into consideration by the output-capital and capital-output ratios calculated for gross output with analogous indicators for standard net product.<sup>5</sup>

As can be seen from Table 2, the factor of repeated counting caused a 6 percent growth in the FEC output-capital ratio and a 10 percent reduction in the capital-output ratio. The role of this factor is most marked in the formation of investment indicators in the fuel extraction sectors. The output of the electrical energy sector is relatively homogenous. The gross output growth rates here were close to the growth rates in physical terms. By 1975 the gross output of electrical energy had increased 2 fold, and energy production 1.9 fold compared to 1966.<sup>6</sup> Therefore, the repeated counting factor in electrical power production was very insignificant. The total effect of the group of structural factors caused a 15 percent change in FEC output-capital ratio and a 12 percent change in the capital-output ratio. Individual factors had diverse effects.

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Table 2  
Factor Analysis of Indices of Output-Capital and Capital-Output Ratios of  
FEC

		1 Электро- энергетика			4 Нефтедо- бывающая промыш- ленность			5 Газовая промыш- ленность			6 Угольная промыш- ленность			7 Итого		
		2		3	2		3	2		3	2		3	2		3
		фондо- отдача	капитало- емкость		фондо- отдача	капитало- емкость		фондо- отдача	капитало- емкость		фондо- отдача	капитало- емкость		фондо- отдача	капитало- емкость	
1		2	3	4	5	6	7	8	9	10	11					
8	Фактическое изменение пока- зателя . . . . .	0,95	1,09	0,83	1,44	0,58	0,72	0,85	0,96	0,83	1,13					
9	в том числе за счет: изменения технологической структуры капиталовлений и основных фондов . . . . .	1,01	0,99	1,04	1,02	0,94	0,89	1,13	0,92	1,02	1,00					
10	повторного счета в валовой продукции . . . . .	1,02	0,97	1,21	1,07	0,98	0,43	1,07	0,91	1,06	0,90					
11	изменений в технологии и производственном аппара- те . . . . .	0,92	1,13	0,66	1,32	0,63	1,89	0,70	1,14	0,77	1,26					
12	из них за счет развития: атомной энергетики . . . . .	0,97	1,05							0,97	1,02					
13	централизации теплоснабже- ния . . . . .	1,02	0,94							0,98	0,98					
14	сетевого хозяйства . . . . .	0,96	1,04							0,95	1,01					
15	буровых работ . . . . .			0,98	1,02	1,00	1,01			1,00	1,01					
16	компенсаций ухудшающихся природных условий при до- быче и первичной обработ- ке нефти и газа . . . . .			0,84	1,04	0,90	1,12			0,98	1,03					
17	добычи нефти из пластов, разрабатываемых с приме- нением методов поддержа- ния пластового давления . . . . .			0,95	1,03					1,00	1,01					
18	трубопроводного транспорта газа . . . . .					0,81	1,11			0,99	1,01					
19	комбайновой выемки угля . . . . .							1,00	1,00	1,01	1,00					
20	добычи угля из забоев, осна- щенных комплексными ме- ханизированными крепями открытого способа добычи угля . . . . .									0,92	1,00	0,99	1,02			
21	обогащения угля . . . . .									0,94	1,03	0,99	1,01			
22	автоматизации производства производственной инфраст- руктуры . . . . .	1,00	1,02	0,98	1,02	0,93	1,03			1,00	1,01	1,00	1,02			
24	ремонта оборудования . . . . .	0,98	1,01	0,90	1,04	0,95	1,05	0,87	1,04	0,97	1,03					
25	прочих факторов . . . . .	1,00	1,00	0,99	1,00	0,98	1,00	1,00	1,00	1,00	1,00					
26		0,98	1,07	0,97	1,14	1,00	1,39	0,93	1,99	0,92	1,10					

\* По данной позиции учтены только затраты на приобретение оборудования для магистраль-  
ных газопроводов.

† Условно чистая продукция рассчитывалась путем вычитания из валовой продук-  
ции материальных затрат.

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Key:

- |   |                                  |                               |              |          |
|---|----------------------------------|-------------------------------|--------------|----------|
| 1. Electrical power engineering   | 4. Petroleum Extraction Industry | 5. Gas Industry               | 6. Coal Ind. | 7. Total |
| 2. Output-capital ratio   | 3. Capital-output ratio          |                               |              |          |
| 8. Actual change in indicator including as a result of:   |                                  | 23. Production automation     |              |          |
| 9. Changes in the technological structure of capital investments in fixed capital                                   |                                  | 24. Production infrastructure |              |          |
| 10. Repeated counting in gross output   |                                  | 25. Equipment repair          |              |          |
|   |                                  | 26. Other factors             |              |          |
| 11. Changes in technology and production apparatus including for the development of:                                |                                  |                               |              |          |
| 12. Atomic energy   |                                  |                               |              |          |
| 13. Centralized heat supply   |                                  |                               |              |          |
| 14. Distribution network operations   |                                  |                               |              |          |
| 15. Drilling operations   |                                  |                               |              |          |
| 16. Compensation for deteriorating natural conditions in the extraction and initial processing of petroleum and gas |                                  |                               |              |          |
| 17. Extraction of petroleum from reservoirs using methods to maintain reservoir pressure                            |                                  |                               |              |          |
| 18. Pipeline transportation of gas*   |                                  |                               |              |          |
| 19. Combine extraction of coal  |                                  |                               |              |          |
| 20. Extraction of coal from faces equipped with comprehensively mechanized pit props                                |                                  |                               |              |          |
| 21. Open pit method of coal extraction  |                                  |                               |              |          |
| 22. Coal enrichment   |                                  |                               |              |          |

\* From this position, only cost for the acquisition of main gas pipeline equipment is included.

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Changes in technology had a decisive effect on the dynamics of the two ratios in the FEC. Measurement of the influence of technological factors is based upon the fact that changes in technology are accompanied by changes in the procurement and stock of the appropriate types of equipment, that is they are reflected in the natural-physical structure of capital investments and fixed capital stocks. In order to analyze the influence of production technology changes on the two ratios a study was made of the natural-physical structure of capital investments, fixed capital stocks (including the stock of equipment in the form of a complex balance of equipment) included in the matrix of equipment deliveries and stocks for 18 sectors of material production and 90 types of equipment expressed in physical value form for the period 1966-1975.

Since the equipment structure in the balance was aggregated, an analysis of the two ratios does not reflect all, but only some of the most important changes in technology. Thus, the nomenclature of equipment in the complex balance does not reflect those changes which involve a growth in machinery operating parameters, for example, the transition to super-critical steam parameters and high temperature heat.

The following relationships were used to estimate the influence of technological factors.

The aggregated type (group) of equipment is designated by  $i = 1, 2, \dots, n$ , where  $n$  is the number of analyzed factors. Since the index of the output-capital ratio for the  $i$ th group of equipment will be equal to  $J_{r_i} = J_B : J_{\phi_i}$ , where  $J_B$  is the index of the growth of sector output (in constant prices) and  $J_{\phi_i}$  is the index of changes in fixed productive capital for the  $i$ th group.<sup>7</sup> The influence of partial indices on the summation for the  $j$ th sector of changes in the output-capital ratio ( $J_{r_j}$ ) depends upon the percentage of each  $i$ th group in sector stocks in the base year ( $d_i^0$ ) and is defined by the expression 1:  $J_{r_j} = \sum_i \frac{d_i^0}{J_{r_i}}$ .

The contribution of factors to output-capital ratio dynamics is determined with the help of indices calculated by the chain method, with the subsequent elimination of the influence of each of them. The product of these indices is equal to the total change in the indicator. Thus, in estimating the contribution of the first factor it was assumed that the equipment stock in the first group changed at the same rates as product output. Then  $J_B = J_{\phi_1}$ , and  $J_{r_1} = 1$ . With the help of the relationship given above, and with this allowance, the index of changes in the output capital ratio of sector  $J'_{r_j}$  was calculated.

The comparison of this index with the actual figure permits the calculation of an index characterizing the contribution of the first factor:

$$J_1 = \frac{J_{r_j}}{J'_{r_j}}.$$

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The contribution of the second factor is calculated on the basis of the assumption that  $J_{r1} = J_{r2} = 1$ . Based on this an index for sectors  $J''r_j$  is determined and an estimate is made of the contribution of the factor:

$$J_2 = \frac{J''r_j}{J''r_j}$$

As a result all selected factors  $J_r = J_1 \cdot J_2 \cdot J_3 \cdot \dots \cdot J_h \cdot J_{rn}$  are analyzed. In this product the last factor is characterized as the contribution of others not taken into consideration in the calculation of factors. The analysis is more complete the closer  $J_r$  approaches 1. However, in the presence of a comparatively large influence of other undiscovered factors the analysis could be effective if the sum  $\sum_i 1/J_i$  is significantly great.

In studying the capital-output ratio the contribution of each factor is estimated with the help of the relationship between the index of change in sector capital-output ratio ( $J_q$ ) from the analogous index for each partial  $i$ th group of equipment ( $J_{q_i}$ ) and the share of the procurements of the  $i$ th type of equipment in the capital investments for its acquisition on an average during the Eighth Five Year Plan ( $dk_i$ ):  $J_q = \sum_i J_{q_i} \cdot dk_i$ .

The procedure for calculating the contribution of each factor was identical to the one previously described. Results from the analysis of the influence of technological factors are given in Table 2.

The dynamics of the technological structure of capital investments and fixed capital stocks of the FEC are characterized by somewhat of a growth in assets of fixed capital stock (27.4 percent in 1975 compared to 26.5 percent in 1966) in face of the practically stable share of equipment in capital investments during the 9th Five Year Plan compared to the 8th. As can be seen from Table 2, the influence of the technological structure factor on the complex output-capital ratio resulted in a slight growth, while capital-output ratio did not change. A more marked growth in the percentage of equipment occurred in the coal and gas industries. As a result the capital-output ratios in these sectors declined by 8-11 percent.

The share of assets increased in the capital stocks of electrical power production, petroleum extraction, and especially in the coal industry, which permitted an increase in return on funds. In the gas industry, however, the share of assets during the decade analyzed was reduced and the output-capital ratio fell correspondingly.

The pace setting rates of development of production infrastructure are one of the characteristics of the FEC during the decade analyzed. This is to a considerable extent caused by increases in energy resource extraction in poorly developed regions in the nation. This has required the development of transportation, especially pipelines, communications, electrical distribution

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systems, centralized heat supply systems, and machinery repair facilities. This has been reflected in the purchase and stocks of the appropriate equipment. The significance of the problem of compensating for shifts in the FEC can be imagined when one takes into consideration the fact the basic growth in energy extraction has occurred in the nation's eastern regions, where, according to the data of Academician N. Mel'nikov and V. Shelest, 90 percent of the potential and 75 percent of the explored energy resources of the nation are located, while concurrently 80 percent of the consumption is located in the European sections of the USSR and the Urals.<sup>8</sup>

The total effect of infrastructural factors has been most significant of all groups of technological factors and explains 11 percentage points in the change in the output-capital ratio and 7 for the capital-output ratio (See Table 2). The influence of regional factors and infrastructure were especially substantial for fuel extracting sectors. As far as electrical energy production is concerned, this factor is manifested above all in the development of electricity and heat networks.

During the period analyzed the nation completed the formation of the Unified electrical energy system for the European part of the USSR. During 1966-1975, with an overall 1.8 fold growth in electrical energy production capacity, the length of electrical power distribution systems of 35 Kvt and higher doubled.<sup>9</sup> During 1966-1975 the growth in fixed capital stocks in electrical distribution systems overtook their growth in electrical power production in general. This required additional purchases of electrical engineering equipment (transformers, circuit breakers, etc.) Since the distribution network yields only an insignificant growth in output, the more rapid growth of network operations has reduced the output-capital ratio and increased the capital-output ratio of electrical power production.

The development of centralized heat supply has had an opposite effect. The share of centralized heat supply in the total production of heat (through TETs, large boilers, and the utilization of industrial heat) has been increased by approximately 1 percent annually.<sup>10</sup> There has been a relative reduction in the procurement and stock of boilers and certain other types of equipment. This has influenced the growth of the output-capital ratio and reduced the capital-output ratio.

The second group of technological factors is, to a considerable extent, linked to changes in natural conditions. It includes changes in technology and the production apparatus caused by the necessity of compensating for deteriorating natural conditions in the extraction and initial processing of petroleum and gas, the maintenance of reservoir pressure during extraction, the development of drilling operations and the open pit extraction of coal. The total effect of these factors has caused a 3 percentage point reduction in the output-capital ratio for the complex and increased the capital-output ratio of the FEC by 6 percentage points.

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The development of the petroleum and gas industry in the eastern regions is characterized by growing unit investment costs for increases in petroleum and gas extraction. Extensive additional resources are being directed towards the development of smaller and deeper deposits of petroleum and natural gas in the European section of the nation. In order to compensate for unfavorable engineering-geological conditions in petroleum extraction and to increase the level of petroleum recovery from reservoirs, progressive methods of reservoir engineering are being introduced at accelerated rates: perimeter and contour flooding, air and gas injection, and hydro fracturing. The percentage of extraction where use is made of methods for maintaining reservoir pressure reached 84 in 1975, compared to 70 percent in 1965.

The transition from natural to pump-compressor extraction of petroleum and the use of secondary recovery methods assisted by water injection requires additional capital investments to acquire pumps, compressors, field, chemical and other equipment. Less capital intensive and more efficient technology, increasing the coefficient of petroleum extraction is now well known and has found practical application. According to N. Feytel'man's data, the addition of surface active substances to injection water increases the coefficient of petroleum extraction by 5-6 percent. Accompanied by somewhat of an increase in current costs, unit capital investments for a 1 ton increase in petroleum extraction amount to 4-5 rubles. The addition of a thickening agent to the injection water reduces unit capital investments to 3-3.5 rubles per ton. Concurrently, the prospects of injecting water solutions of carbonic acid or carbon dioxide have turned out to be more capital intensive as a result of considerable transportation expenditures. Using such technology, capital investments increase to 30-65 rubles per ton.<sup>11</sup>

The development of the coal industry primarily involves the exploitation of deposits in eastern regions having favorable mining-geological conditions. These deposits are mainly being developed by open pit methods. The share of coal extraction by this method had increased to 32 percent in 1975 compared to 24 percent in 1965.

The output capital ratio of coal extraction by the open pit method is about 2.5 fold higher than for the shaft method. However, during the period analyzed it dropped faster at open pits than at shafts. The growth of the stock and deliveries of open pit equipment surpassed deliveries of other types of machinery to the coal industry. Therefore, during the period analyzed the increase in the percentage of open pit extraction reduced the sector's output-capital ratio.

The third group of technological factors is linked to economies in live labor and improvements in its conditions. This group includes such factors as automation, the extraction of coal from faces equipped with comprehensively mechanized pit props, and the extraction of coal by combines. The total effect of this group of factors accounts for two percentage points in the change in the output-capital ratio and four in the capital-output ratio.

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Many processes in power engineering and the fuel sectors are easily automated. Therefore, a considerable stock of automation equipment has already been created. The share of measuring and control instruments, and laboratory equipment amounted to 1.2 percent of the value of fixed capital in electrical power engineering and about 1 percent in the coal industry. This is somewhat higher than in other sectors. For the FEC as a whole it averages about 1 percent.

Since the percentage of costs for the acquisition of instruments, automation equipment and computer technology is considerably higher in FEC sector capital investments than in capital stocks (about 2.3 percent during 1971-1975), the share of automation equipment in capital stocks will grow in the future. The automation process has influenced the growth and capital intensity of all sectors in the FEC and has reduced the output-capital ratio in the petroleum and gas industries.

The increase in the unit capacity cost of equipment has influenced the dynamics of the two ratios in the FEC. Because of imperfections in indices for calculating machinery building output in constant prices, the estimate of the contribution of factors based on such factors only partially reflects the influence of equipment unit capacity cost.

The determination of the value of power engineering and electrical engineering equipment per unit of capacity is based on data on production value in value form (in prices of 1 Jan 67) and in units of capacity. The unit capacity value of all power engineering equipment is calculated on the basis of non-identified units of such capacity by means of analogous indicators for individual types of pipe and boilers which have been made according to equipment output value.

From Table 3 it is apparent that during the period analyzed the average unit capacity cost of power engineering (boilers and turbines of all types) increased by 25 percent. The same data for the 8th and 9th five year plans show an increase in unit capacity power engineering costs of approximately 10 percent, and 16 percent for electrical engineering equipment.

Since data is lacking on production volumes of other types of equipment in the FEC measured in terms of capacity, an indirect approach was made to the determination of unit capacity costs. It was based upon calculating costs for essential equipment to develop production capacity. The magnitude of these costs was assumed to be equal to procurements of the appropriate basic equipment in each sector in the FEC, excluding costs for equipment wear and changes in stocks of uninstalled equipment ("net investments"). If these data are related to the growth in production capacity in electrical power production, coal, petroleum, and gas, one can calculate the magnitude of costs for basic equipment per unit of capacity.

The results obtained with the help of the indirect method indicated that during 1971-1975 costs for basic equipment necessary to create a unit of production capacity in electrical power production increased by 27 percent compared to

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Table 3.  
Dynamics of Unit Capacity Cost of Basic Technological Equipment in Electrical  
Power Engineering<sup>12</sup>

Equipment Оборудование	Units of Единица измерения Measure	Year    Годы			Growth Index 1973 as % of 1966
		1966	1970	1973	
1 Энергетическое оборудование, всего	17 тыс. руб.	0,0213	0,0215	0,0267	1,25
2 Турбины паровые	ед. мощности 18 руб.	7,2	6,6	6,9	0,96
3 Турбины газовые	— " — квт.	51,6	55,5	46,2	0,90
4 Турбины гидравлические	— " — квт.	9,3	8,6	10,5	1,13
5 Котлы паровые малой мощности про- изводительностью от 0,1 до 10 т пара/час	19 тыс. руб. т пара/час	1,0	1,6	2,2	2,2
6 Котлы паровые свыше 10 т пара/час	— " —	2,4	2,7	2,7	1,1
7 Котлы-утилизаторы, включая энерге- тические	— " —	1,4	3,0	2,4	1,7
8 Котлы теплофикационные водогрей- ные производительностью свыше 10 гкал/час	20 тыс. руб. гкал/час	0,81	0,80	0,85	1,0
9 Электротехническое оборудование, всего	21 тыс. руб. тыс. квт.	0,0041	0,0050	0,0052	1,27
10 Генераторы к паровым и газовым тур- бинам	22 тыс. руб. квт	0,0036	0,0032	0,0032	0,9
11 Генераторы к гидравлическим турби- нам	— " —	0,0096	0,0099	0,0097	1,0
12 Электродвигатели переменного тока мощностью от 0,25 до 100 квт	— " —	0,0100	0,0119	0,0132	1,3
13 Электродвигатели переменного тока мощностью свыше 100 квт	— " —	0,0075	0,0086	0,0086	1,1
14 Электродвигатели взрывобезопасные	— " —	0,0147	0,0164	0,0175	1,2
15 Преобразователи силовые мощностью 0,5 квт и выше	— " —	0,0053	0,0075	0,0098	1,8
16 Трансформаторы силовые	— " —	0,0020	0,0026	0,0024	1,2

Key: A. Growth Index, 1973 comp.  
to 1966

1. Power engineering equip. total.
2. Steam turbines
3. Gas turbines
4. Hydroelectric turbines
5. Small capacity steam boilers,  
productivity from 0.1 to 10 tons  
of steam per hour
6. Steam boilers over 10 tons per  
hour
7. Boilers, heat recovery units,  
including for power engineering

8. Central heat supply boilers  
productivity over 10 gcal/hr.
9. Electrical engineering equip  
total
10. Generators for steam and gas  
turbines
11. Hydrogenerators
12. AC electric motors (.25 to 100kw)
13. AC motors over 100 kw
14. Explosion proof electric motors
15. Power transformers, 0.5 kw and  
over

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Key to Table 3, cont:

16. Power transformers	20. <u>Thousands of rubles</u>
17. <u>Thousands of rubles</u>	<u>Gigacalories per hour</u>
Unit capacity	21. <u>Thousands of rubles</u>
18. <u>Rubles</u>	<u>Thousands of kilowatts</u>
Kilowatts	22. <u>Thousands of rubles</u>
19. <u>Thousands of rubles</u>	<u>Kilowatts</u>
Tons of steam per hour	

1966-1970. For electrical engineering equipment the increase was 26 percent. This agrees well with the above presented estimates of unit capacity cost dynamics where the more accurate method was used in the calculations for these groups of equipment. In the gas industry the costs of equipment to create a unit of production capacity increased 2.4 fold and in the coal industry 1.5 fold.

The replacement of technically and physically obsolescent equipment has had an important influence on the FEC capital-output ratio. According to our studies growth in the percentage of investments to replace equipment increased the FEC capital-output ratio by at least 10 percentage points. The degree of this factor's influence varied in electrical power production and the fuel industry. In electrical power production replacement increased somewhat more rapidly than investments in equipment. However, its relative importance in the sector's capital investments continues to stay low and the influence of this factor on capital-output ratio dynamics was insubstantial. On the other hand, equipment in the fuel sector is distinguished by its short service life. In the gas, and especially in the coal industry, the share of replacement in capital investments during the 9th Five Year Plan was substantially higher than in the 8th. The replacement factor caused the capital-output ratios in these sectors to increase. In the petroleum extraction industry the percentage of equipment replacement costs during the 10 year period analyzed did not grow significantly and had little effect on changes in the capital-output ratio.

Environmental protection costs have had a significant influence on the growth in the capital-output ratio and the reduction of the output-capital ratio. Sectors in the FEC now account for about 15 percent of capital investments allocated to environmental protection and the rational use of natural resources. Of this total 45 percent are spent in power engineering, and 20-25 percent in the coal industry. More than 80 percent of capital investments allocated to FEC sectors for environmental protection go to protecting water resources, 6-8 percent for protecting the land and the air sheds. The coal industry spends about two-thirds of all expenditures for protecting land and mineral resources in the national economy.

Environmental protection costs in FEC sectors are annually increasing by 4-5 percent. However, during the period analyzed they did not substantially influence the capital-output ratio, since capital investments for environmental protection are a small percentage of total FEC capital investments.

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Production organization has a growing influence on the output-capital ratio. From Table 2 it is apparent that the accelerated development of equipment repair by the "economic" method, requiring large expenditures for expanding the stock of machine tools, not to mention irrational use of skilled labor and metal, has reduced the output-capital ratio and increased the capital-output ratio. As a result of decentralized repair, a stock of machine tools has been concentrated in electrical power engineering which exceeds the stock in power engineering machinery building by 50 percent. For example, during 1966-1975 a 1.9 fold growth in electrical energy production was obtained with a 1.8 fold growth in electric station capacity.<sup>13</sup>

The utilization of production capacity and fixed capital depends to a great extent upon the availability of the work force. In this regard an analysis of labor productivity was made for individual groups of equipment. The following groups of workers were distinguished: servicing basic process equipment, machinery repair; loading transportation operations; servicing production infrastructure.

The comparison of indices for labor productivity growth and the stock of equipment for these groups indicates that in the majority of cases, the growth rate of equipment is considerably more rapid than that of labor productivity. This situation, for example, is characteristic for production infrastructure in electrical power production and the coal industry, and basic equipment in the petroleum extraction industry. In such cases even the maintenance of existing levels of equipment utilization requires attracting additional workers to the sector.

Concurrently, the growth of labor productivity surpassed the increase in the equipment stock for the basic technological processes in loading and transportation operations in electrical power production, in the coal industry, and for certain other groups.

From Table 4 it is obvious that for the three sectors in the FEC, modernizations in design, improvements in the organization of labor, and reductions in the number of management personnel have had the greatest effect upon labor productivity growth. Improvements in the organization of repair, the development of production infrastructure, and the mechanization of loading and transportation operations had practically no effect on labor productivity in any of the three sectors.

For all sectors examined, partial indices for labor productivity were the highest for workers in the leading professions, occupied in basic technological processes. Labor productivity here increased by 1.4-2 fold. If one removes from this group those workers engaged in servicing turbines and boilers, then, with a total growth in labor productivity which was significant (2 fold), the influence of this relatively small (4 percent of total workers) on labor productivity in electrical power engineering was only 2 percent. Therefore, increases in the unit capacity and operating parameters of important power engineering equipment, which are accepted as one of the

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Table 4  
Factor Analysis of the Growth of Labor Productivity in the FEC during  
1966-1975 for Various Groups of Equipment

Factor  Наименование фактора	1 Электро- энергетика*			2 Нефтедобы- вающая промышленность			3 Угольная промышленность		
	4 индекс роста парка	5 индекс роста производства и стоимости фактора на рост произво- дительности тру- да	6	4 индекс роста парка	5 индекс роста производства и стоимости фактора на рост произво- дительности тру- да	6	4 индекс роста парка	5 индекс роста производства и стоимости фактора на рост произво- дительности тру- да	6
7 Рост производительности труда и активной части основных произ- водственных фондов . . . . .	1,53	1,28	1,28	2,33	1,43	1,43	1,07	1,41	1,41
8 в том числе: совершенствование конструкций основного технологического обо- рудования и организации труда в основных технологических про- цессах . . . . .	1,73	1,05	1,17	2,54	1,44	1,13	1,73	1,72	1,34
9 совершенствование организации ремонта . . . . .	2,06	1,22	1,02	2,06	1,10	1,02	1,04	1,01	1,00
10 механизация подъёмно-транс- портных работ . . . . .	1,31	1,60	1,01	—	0,86	1,00	1,33	1,50	1,02
11 развитие производственной ин- фраструктуры и повышение про- изводительности труда на тран- спорте и в других ее отраслях . . . . .	2,79	1,07	1,00	2,05	1,73	1,02	1,68	1,18	1,01
12 влияние развития и совершенст- вования организации труда уп- равления . . . . .	—	1,47	1,13	—	1,54	1,34	—	1,30	1,07

\* Calculated for 1969-1975

- |   |  |
|---|--|
| <p>Key: 1. Electrical power engineering</p> <p>2. Petroleum extraction industry</p> <p>3. Coal industry</p> <p>4. Index of capital stock growth</p> <p>5. Index of labor productivity growth</p> <p>6. Influence of factor on labor productivity growth</p> <p>7. Growth of labor productivity and assets of fixed productive capital including</p> <p>8. Improvement in design of basic technological equipment and labor organization in basic technological processes</p> <p>9. Improvement of repair organization</p> | <p>10. Mechanization of loading and transportation operations</p> <p>11. Development of production infrastructure and increased labor productivity in transport and other sectors</p> <p>12. Influence of the development and improvement of administration labor organization</p> |
|---|--|

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main directions of technical progress in power engineering have only an insignificant effect on labor productivity growth in this sector. The main contribution to this indicator for groups of basic workers was made by electrical installation workers, the share of which accounts for more than 25 percent of all workers in electrical power production.

With respect to auxiliary production processes, high rates in labor productivity growth for loading and transportation operations were attained in electrical power production (1.6 fold) and in the coal industry (1.5 fold). However, this indicator declined in the petroleum extraction industry. There was a markedly smaller increase in the productivity of workers engaged in equipment repair and servicing production infrastructure. As a rule, it did not exceed 20-25 percent over 10 years, that is, 2-2.5 percent annually.

When one takes into consideration the considerable percentage of auxiliary workers (from 30 to 40 percent of the analyzed sectors were in the three groups above), then it becomes obvious that it is necessary to speed up improvements in equipment design for auxiliary processes, completely supply them with machinery, and, what is especially important, increase the requirements made upon labor organization.

Thus, the tasks which sectors in material production now face, that of further increasing production volume without substantial increases in the number of employees, i.e. through increases in labor productivity, cannot be solved in FEC sectors by the traditional method - increasing the unit capacity and productivity of basic equipment. The leading role in the solution of this task belongs to the development of the technology and the production apparatus of auxiliary processes.

What will be the future tendencies in the dynamics of the output-capital ratio and the capital-output ratio in the TEC?

Since at the present time the capital-output ratio (kapitaloyemkost') and the incremental output-capital ratio of the TEC exceed the average sector output-capital ratio (fondoyemkost'), primary attention should be given to stabilizing, and later reducing the capital-output ratio. Only after this can it be possible to pose the question of increasing the output-capital ratio of the FEC.

The further growth of the FEC capital-output ratio is affected by objective factors. First is the pioneering role of this sector in the development of new economic regions, where production infrastructure is lacking. Second is the necessity of solving such scientific-technical problems of a national economic scale as that of increasing the coefficient of petroleum extraction from 41-45 percent to 80-90 percent, increasing the extraction of light fractions during refining, transporting all types of fuel and electrical energy over long distances, and improving labor conditions in extracting sectors. Third is the increased attention towards social problems, protecting the environment, including a sharp increase in the volume of land restoration, and the protection of people from certain harmful effects of the complex's technological processes.

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The main factors assisting in the growth of the capital-output ratio in the future are still the regional factor and the development of production infrastructure, as well as the necessity of compensating for deteriorating natural conditions in fuel extraction. The influence of the regional factor and the development of production structure on capital-output ratio growth will be less important.

On the other hand, the negative influence of compensating for deteriorating conditions in fuel extraction upon investment indicators will grow further in connection with expanded petroleum extraction from wells with a low flow rate, work in permafrost conditions, on the continental shelf, and the development of thin inclined coal beds in extraction regions. The depth of well drilling and the volume of geological exploration and operational drilling per unit of extracted fuel will increase. Production automation and environmental protection will have an intensified effect on FEC capital-output ratio growth. However, the share of capital investments allocated for these purposes will hardly exceed 3-4 percent of total investments.

In addition to these, there are objective grounds for the development of a group of factors causing reductions in FEC capital-output ratios. These include above all machinery building - the reduction of the cost of power engineering, electrical engineering, and transportation equipment per unit of productivity (capacity), which can primarily be attained as a result of specializing machinery building operations and reducing product metal intensity as well as improving the longevity and reliability of mining and fuel transportation equipment.

The further development of capital saving technology - open pit coal mining, centralized heat supply, etc, can also influence reductions in this ratio.

New and still insufficiently studied possibilities for reducing capital intensity could be opened by the use of basically new technology in the FEC: preparing reservoirs with the help of nuclear explosions, lasers, powerful electrical charges, the application of magnetic and electrical fields to productive horizons, the vacuum operation of wells, the application of the phenomenon of superconductivity, etc.

Great possibilities for obtaining additional output from existing capital stocks and reducing output capital intensity are opened by the improvement of production organization, in particular the centralized repair and production of spare parts, the improvement of equipment time utilization where it is operating under discrete conditions, especially motor vehicle transportation, and increasing the amount of equipment available for auxiliary processes.

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Thus, the reduction in the output-capital ratio and the growth in the capital-output ratio of the complex are not inevitable. The tendencies in these two FEC ratios' dynamics depend decisively upon the degree of success in realizing the potentials of machinery building, the development of capital saving technology and the simultaneous improvement in the organization of the production apparatus' utilization.

FOOTNOTES

1. The share of fuel and energy in the structure of USSR exports grew from 17 percent in 1965 to 31 percent in 1975. (Cf NARODNOYE KHOZYAYSTVO SSSR V 1975 (USSR National Economy in 1975)), Statistical Annual, Izdatel'stvo Statistika, 1976, p 756.
2. Cf NARODNOYE KHOZYAYSTVO SSSR V 1975 p 213, NARODNOYE KHOZYAYSTVO SSSR V 1970, 1971, p 160.
3. A 10 percent growth rate corresponds to calculations of the capital-output ratio with a lag of 2 and 3 years, a 15 percent rate - to a 1 year lag.
4. NARODNOYE KHOZYAYSTVO SSSR V 1975, pp 235, 239.
5. Net product is conditionally calculated by deducting material costs from gross product
6. NARODNOYE KHOZYAYSTVO SSSR V 1975 pp. 196, 235.
7. The indicator  $J\phi_i$  is calculated from data on the value of the stock of the  $i$ th group of equipment, obtained from the matrix of the complex balance of equipment.
8. PLANOVOYE KHOZYAYSTVO (Planned Economy), No 2, 1975, p 11.
9. NARODNOYE KHOZYAYSTVO SSSR V 1975 p 235, 238.
10. "Elektrifikatsiya SSSR. 1967-1977" (Electrification of the USSR. 1967-1977) Izdatel'stvo Energiya, 1977, p 117.
11. VOPROSY EKONOMIKI (Problems of Economics), No 10, 1978, pp 12-13.
12. Similar results were obtained by A. Varshavskiy and L. Suvorina (Cf. "Tseny i tsenoobrazuyushchiye faktory" (Prices and Price Formation Factors) NIITSen, Moscow, 1977, pp 43-44.
13. NARODNOYE KHOZYAYSTVO SSSR V 1975, p 235.

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